БАЗЫ ДАННЫХ СИСТЕМЫ МЕДЛЕННОГО КОНТРОЛЯ ДЕТЕКТОРА ATLAS.

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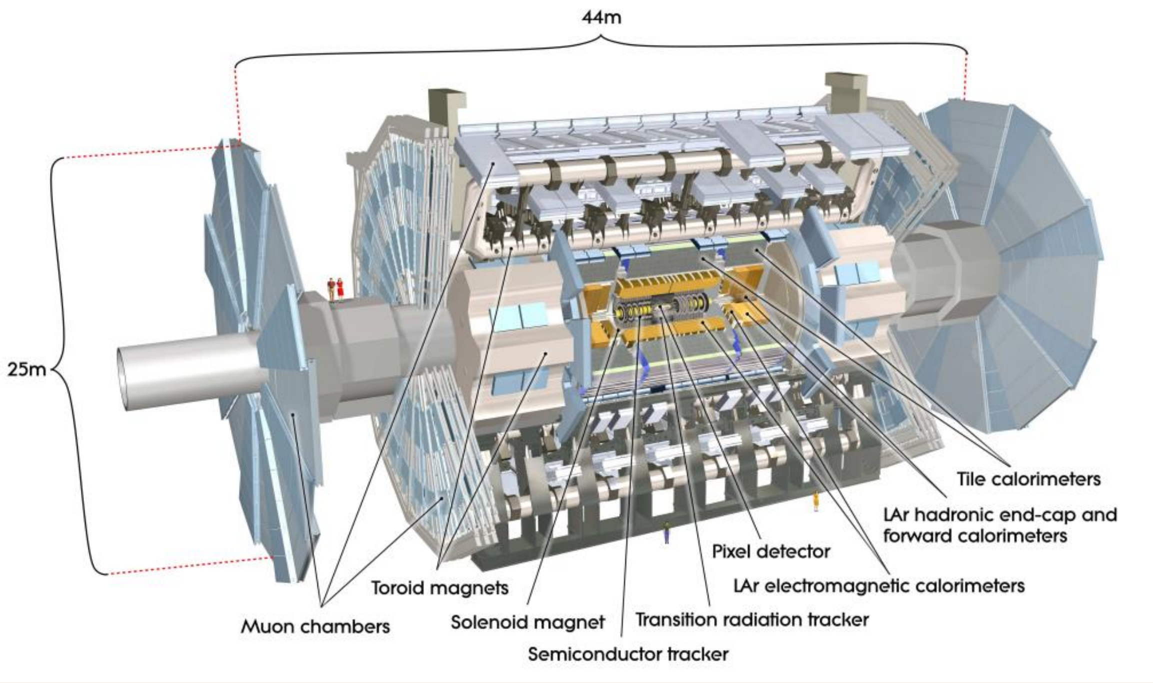
План доклада

1. Детектор ALTAS
2. DCS – системы контроля детектора
3. Программное обеспечение
4. Базы данных
5. Модернизация программного обеспечения

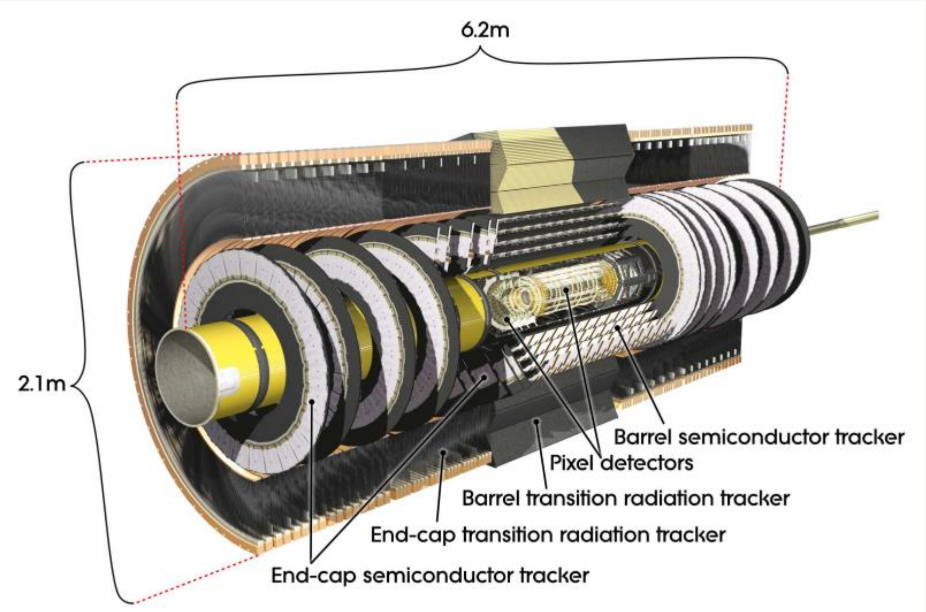
1. Детектор ALTAS.



Cut-away view of the ATLAS detector. The dimensions of the detector are 25 m in height and 44 m in length. The overall weight of the detector is approximately 7000 tonnes.

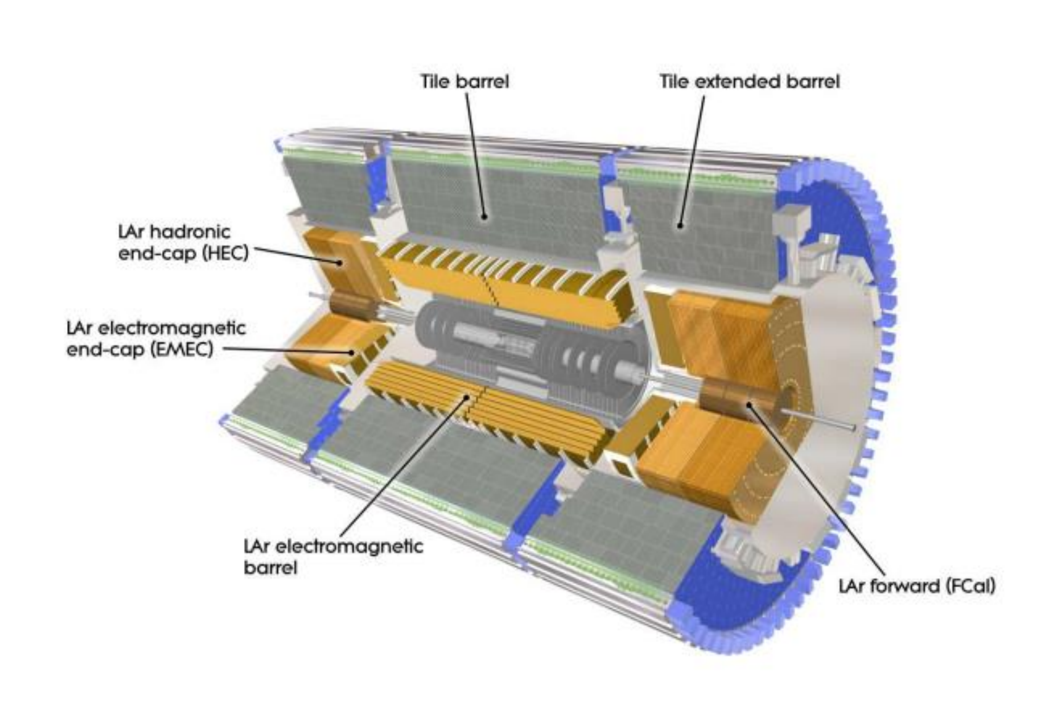
Detector component	**Required resolution**	**η coverage**	
		Measurement	Trigger
Tracking	$\sigma_{p_T}/p_T = 0.05\%\ p_T \oplus 1\%$	± 2.5	
EM calorimetry	$\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$	± 3.2	± 2.5
Hadronic calorimetry (jets)			
barrel and end-cap	$\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$	± 3.2	± 3.2
forward	$\sigma_E/E = 100\%/\sqrt{E} \oplus 10\%$	$3.1 < \|\eta\| < 4.9$	$3.1 < \|\eta\| < 4.9$
Muon spectrometer	σ_{p_T}/p_T=10% at p_T = 1 TeV	± 2.7	± 2.4

1. Детектор ALTAS. Inner detector



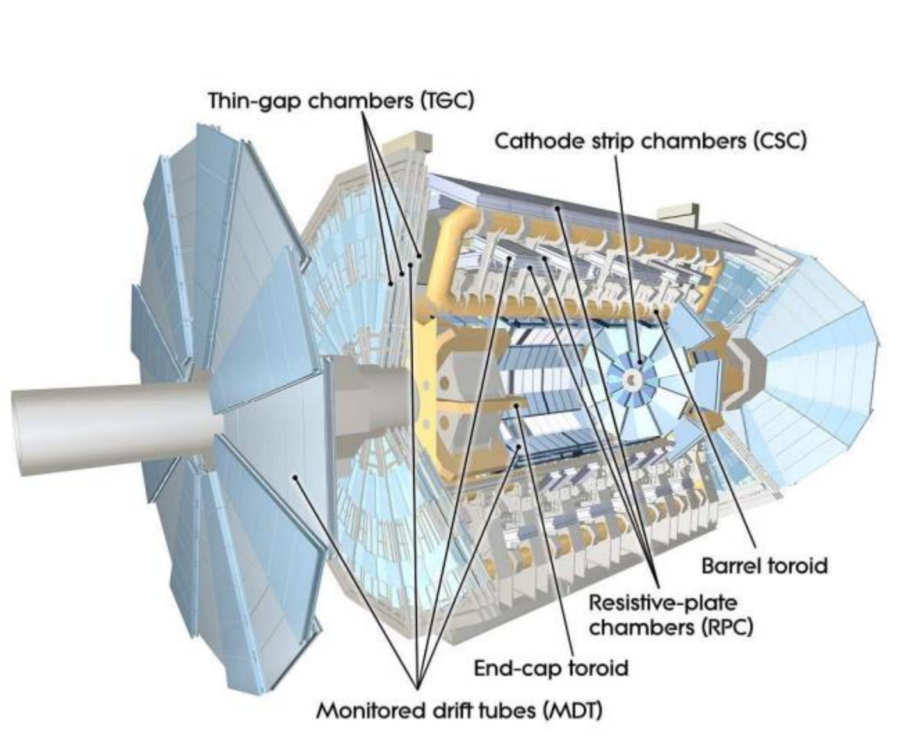
- precision tracking detectors:
  - Pixels
  - SCT – silicon microstrip
- Transition Radiation Tracker (TRT)

1. Детектор ALTAS. Calorimeter system



- LAr electromagnetic calorimeter
- Hadronic calorimeters
  - *Tile calorimeter*
  - *LAr hadronic end-cap calorimeter*
  - *LAr forward calorimeter*

1. Детектор ALTAS. Muon system



- Monitored drift tubes MDT
- Cathode strip chambers CSC
- Resistive plate chambers RPC
- Thin gap chambers TGC

2. DCS

The detector control system for the ATLAS detector was designed and implemented within the frame of the Joint Controls Project (JCOP), a collaboration of the CERN controls group and DCS teams of the LHC experiments. Standards for DCS hardware and software were established together with implementation policies both, commonly for JCOP and specifically for ATLAS. This includes field buses, protocols, and the common SCADA, PVSS II. The aim of a common approach is to reduce the manpower needed for development and maintenance.

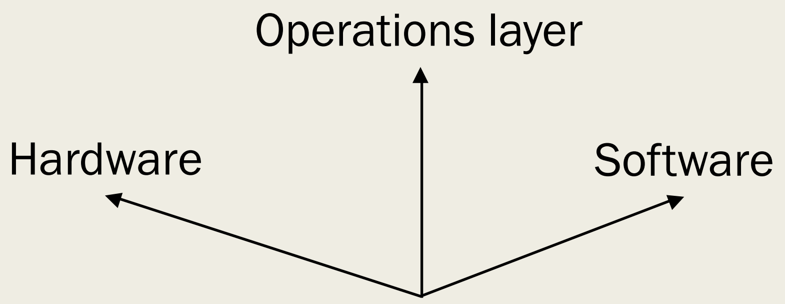
Целью общего подхода является сокращение рабочей силы, необходимой для разработки и обслуживания.

Система осуществляет мониторинг параметров окружающей среды

- параметров окружающей среды – температура, влажность
- настройка и мониторинг электроники детектора FE
- контроль и мониторинг источников питания

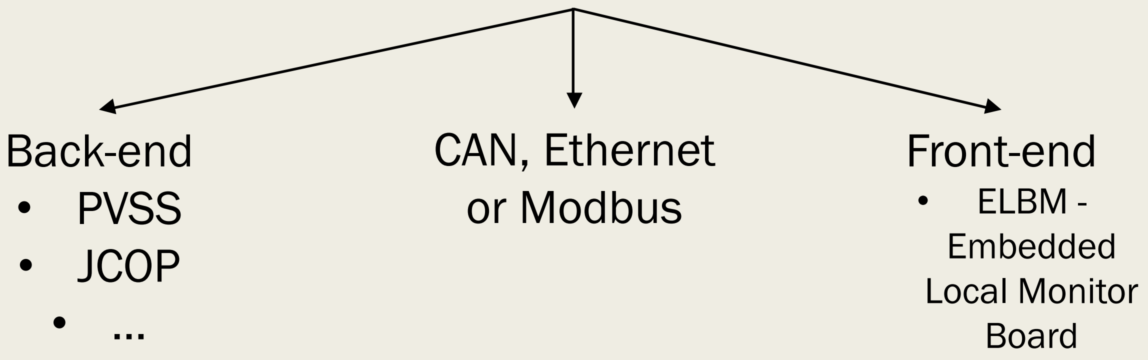
2. DCS

- Архитектуру DCS можно разделить на Front-end (FE) и Back-end (BE): первая часть включает аппаратное обеспечение DCS, такое как источники питания, датчики окружающей среды или контуры охлаждения. Вторая, серверная часть обозначает программное обеспечение, используемое для интеграции внешних элементов управления, продукт промышленного диспетчерского управления и сбора данных (SCADA). PVSS служит в качестве базового программного обеспечения, а программные компоненты структуры JCOP облегчают интеграцию стандартных аппаратных устройств и реализацию однородных приложений управления.
- *Embedded Local Monitor Board (ELMB)*
- *supervisory control and data acquisition software package (SCADA)*
- *Joint Controls Project (JCOP)*
- *Prozess Visualisierungs - and Steuerungs System (PVSS II) – Система визуализации и контроля процесса*

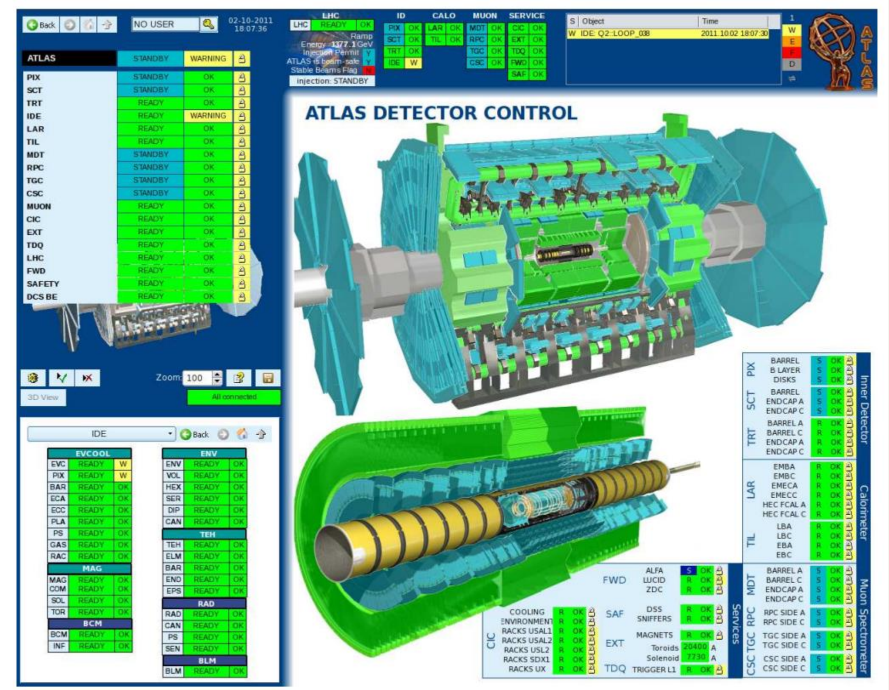


- DCS – Detector Control System

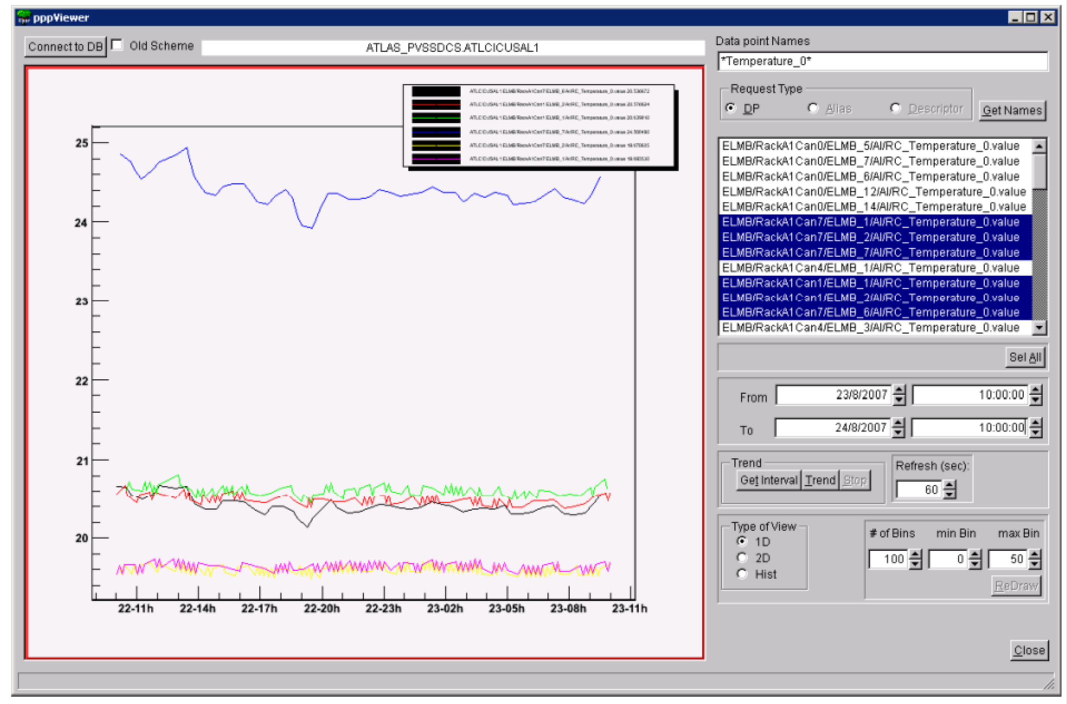
(https://twiki.cern.ch/twiki/bin/viewauth/Atlas/AtlasDcs)



3. ПО систем контроля. Operations layer.

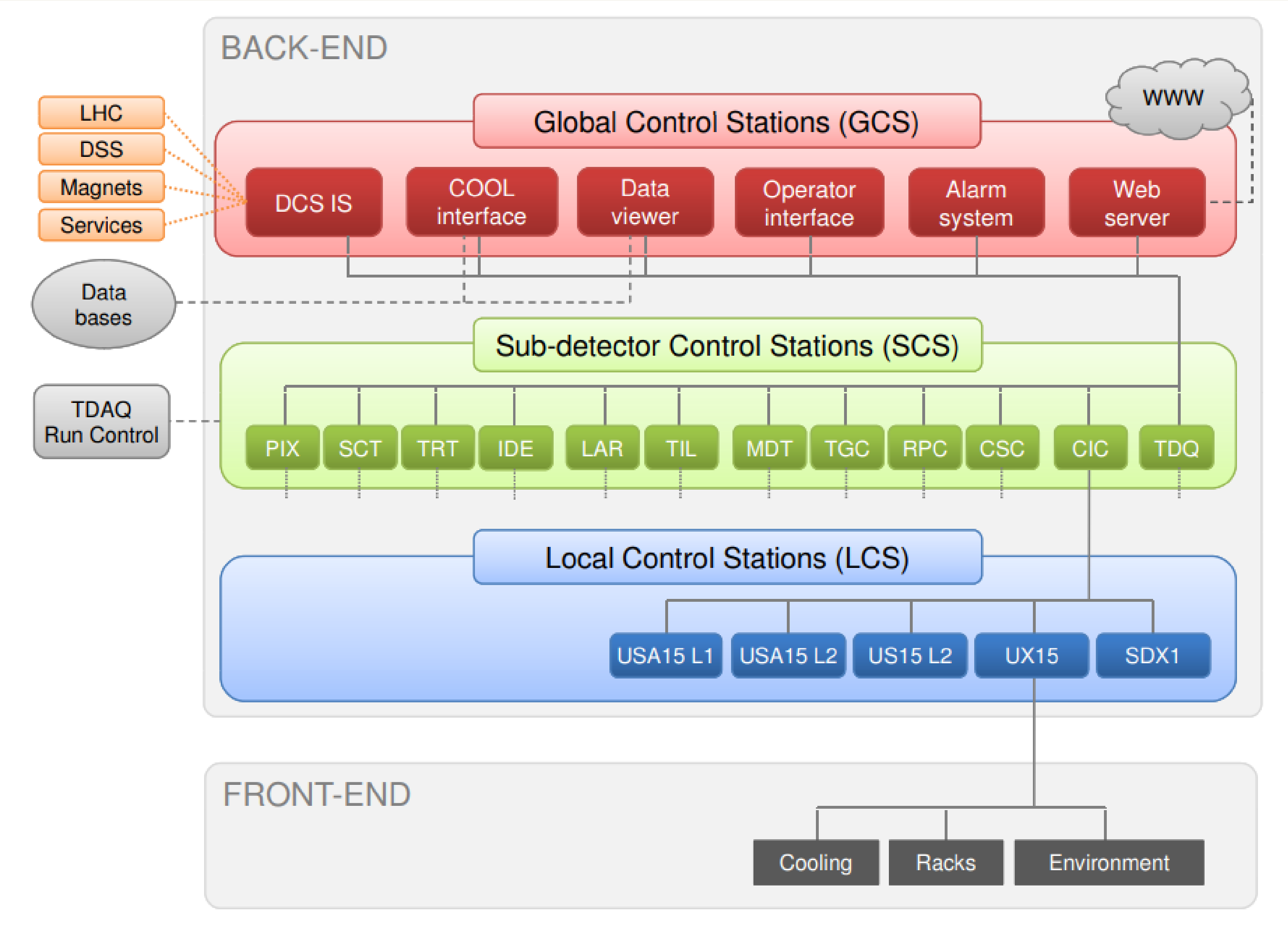


Operator interface (FSM Screen) showing the detector in STANDBY configuration during LHC ramp-up



Root viewer showing multiple parameter values over time

2. DCS. Hardware and software components



The back-end is organised in 3 layers: the Local Control Stations (LCS) for process control of subsystems, the Sub-detector Control Stations (SCS) for high-level control of a sub-detector allowing stand-alone operation, and the Global Control Stations (GCS) with human interfaces in the ATLAS control room for the overall operation

In general, important requirements for the DCS FE I/O are:

- low cost (i.e. use of commercial components),
- low power consumption,
- high I/O channel density (In/Out). If the FE I/O electronics is located in the detector cavern there are additional requirements to be met:
- remote firmware upgrades must be possible,
- insensitivity to magnetic fields,
- tolerance to the radiation levels present at that location, integrated over the lifetime of the experiment.

Common Infrastructure Control (CIC)

3. ПО систем контроля. Hardware and software components

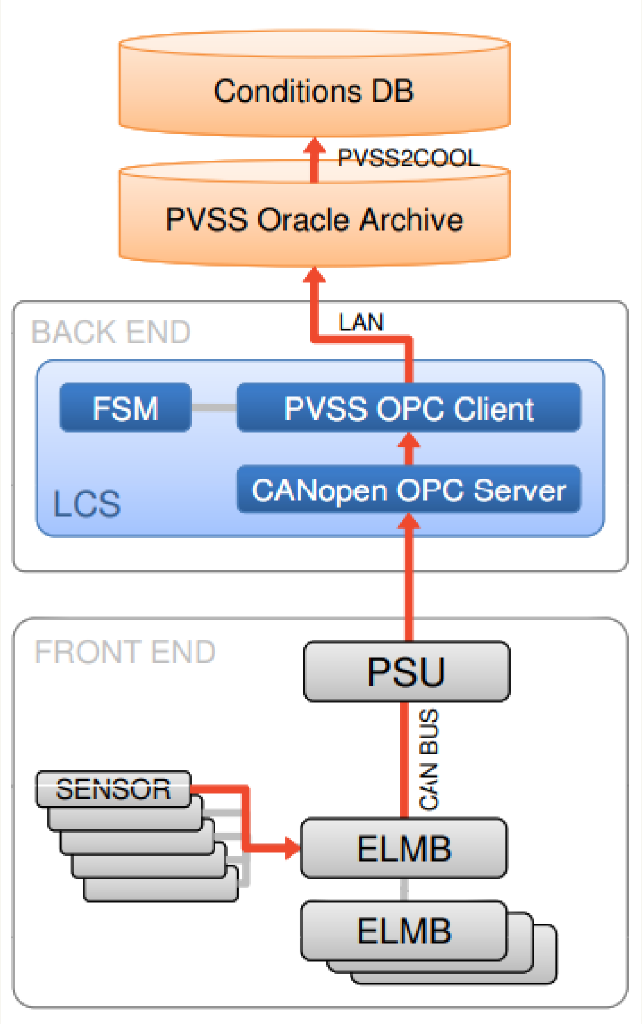
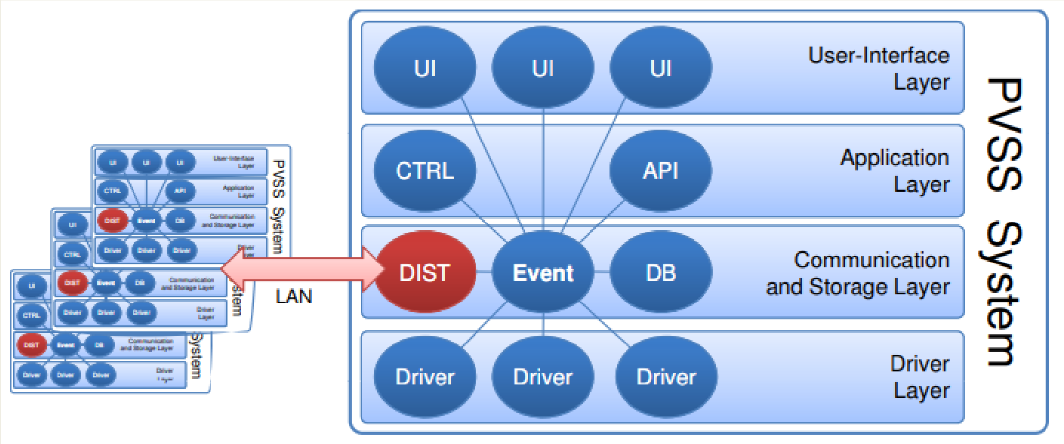


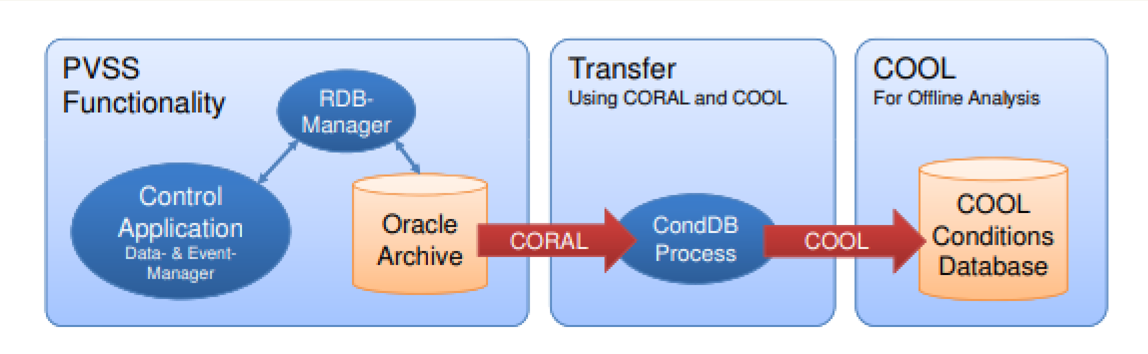
Figure shows a typical example of the readout chain based on the ELMB. The ELMB are placed in the ATLAS cavern and gather data from sensors that are distributed over the whole detector volume. Any ELMB node can be configured to transmit the calibrated sensor data either at regular time intervals or on-change. In the latter mode, which compares the readings against pre-defined thresholds, a first level of data reduction is achieved. All ELMB are interfaced to an associated LCS in the underground counting rooms via CAN. These CAN buses are operated at 125 kbaud allowing a maximum bus length of about 500 m. In total, 63 ELMB can be daisy chained on a single CAN bus and are powered over the bus cable by dedicated power supplies. These power supplies are located in the counting room thus enabling to power cycle all nodes in a bus in case of errors. They also monitor the current consumption of the buses in order to detect aging effects of the ELMB due to radiation.
Embedded Local Monitor Board (ELMB)

3. ПО систем контроля. Software. PVSS



- *Prozess Visualisierungs - and Steuerungs System (PVSS) - Process visualization and control system*
- A control station (PC) runs a so-called “Project” which contains a number of processes, called “Managers”. Different types of Managers may be used depending upon the type of application the Project is being used for, therefore avoiding unnecessary overhead.
- Each PVSS Project uses a central database for all current data values, stored in objects called “Datapoints”. All Managers have full database access for which PVSS provides transparent synchronization. Data processing is performed in an event-based approach using multithreaded callback routines upon value changes.
- Different Projects can be connected via LAN to form a “Distributed System” allowing to remotely access the databases and events of all connected Projects. This provides scalability up to the full size of the ATLAS DCS with in excess of 150 different control stations.
- A generic Application Programming Interface (API) allows to extend the functionality of control applications using additional software components.

4. Базы данных



The ATLAS DCS configuration database (ConfDB) is designed to manage the setting of the detector and DCS parameters (such as calibration constants, voltage settings, and alarm thresholds) depending upon the operation mode of the experiment. Furthermore, it stores the configuration of DCS equipment. The ConfDB is arranged as a set of Oracle databases (one per sub-detector) available for all DCS applications. ConfDB access is based on the Configuration DB FW component which defines the data model comprising two main entities.

- A “Configuration” contains sets of devices with their static properties, for example HW addresses, archiving settings, etc.
- The “Recipe” is a set of values that are run-time specific, such as set points for output channels and alert thresholds, which may change depending on the detector operation mode.

In order to provide direct and easy access to the PVSS Oracle archive to collaboration members, a dedicated web-based data viewer (DCS Data Viewer: DDV) was developed.

The ATLAS detector conditions data are stored in a relational database (CondDB) for efficient access by any offline calibration, reconstruction, and analysis applications. The database is accessed by a dedicated API, called COOL, and was highly optimized for the offline applications only instead of being used for diagnosing detector problems.

4. Базы данных. COOL

The amount of data stored in the CondDB must be kept to a minimum because of the two following main reasons:

- the conditions data must be replicated to external sites for analysis and reconstruction all over the world
- extensive data processing is required for analysis, therefore searching large amounts of conditions data for the required information is an unnecessary overhead.

COOL stores logically grouped data into “folders”. Similarly, PVSS has the concept of Datapoints that hold real-time data from FE equipment, grouped in a structure for a given device. Therefore, a dedicated process — PVSS2COOL — reads selected PVSS data from the PVSS archive database using a generic access API (CORAL), maps the data from PVSS Datapoints into COOL folders of a corresponding structure, and writes it into the CondDB (see figure 7). Datapoint types, which represent devices, are associated with corresponding folders, which will then allow data from one or more of each type of device to be stored in the folder. The configuration for the COOL folders and the data they should contain is defined within PVSS, allowing the sub-detector DCS experts to structure the data for offline analysis. Once the configuration is completed, PVSS2COOL is used to create the folders in the COOL database. After the folders have been created, the transfer process runs at predefined time intervals, replicating and transposing the data into the format required for COOL. For performance reasons, the time intervals for bulk data transport must be optimized. Short time intervals result in performance losses due to increased transaction overhead. Large time intervals will not only delay the availability of data, but may cause the amount of data to be transferred exceeding a tolerable limit.

5. Модернизация программного обеспечения систем контроля

Проект новой базы данных условий был начат по нескольким причинам. Кэширование БД COOL плохо оптимизировано, поскольку запросы, определенные с использованием разных границ IOV, могут возвращать одни и те же данные полезной нагрузки: это влияет на некоторые рабочие процессы обработки данных. Структура БД COOL сложная: данные условий разбросаны по 30 схемам и 10 тыс. папок (около 1 ТБ за период сбора данных). Каждое системное изменение соответствует новому набору папок. Долгосрочное обслуживание и развитие COOL проблематичны: COOL API (как и CORAL) не будет поддерживаться ИТ-подразделением CERN после запуска Run3. COOL не имеет встроенной поддержки управления глобальными тегами.

CREST → COOL

Новый автономный механизм геометрии в настоящее время может создавать постоянную копию описания детектора в двух форматах: SQLite и JSON. Для этого прототипа была выбрана версия JSON, и файл представлен в базе данных условий как тип BLOB-объекта, связанный с одним, так называемым интервалом достоверности (IOV, который определяет время, в течение которого данные объявляются «действительными»). , и который простирается от 0 до бесконечности) и к одному тегу, который может соответствовать предыдущему упомянутому тегу геометрии.Для этих тестов использовался прототип базы данных CREST, развернутый на Openshift в ЦЕРНе, а также клиентские библиотеки Python для взаимодействия с сервером CREST через REST.

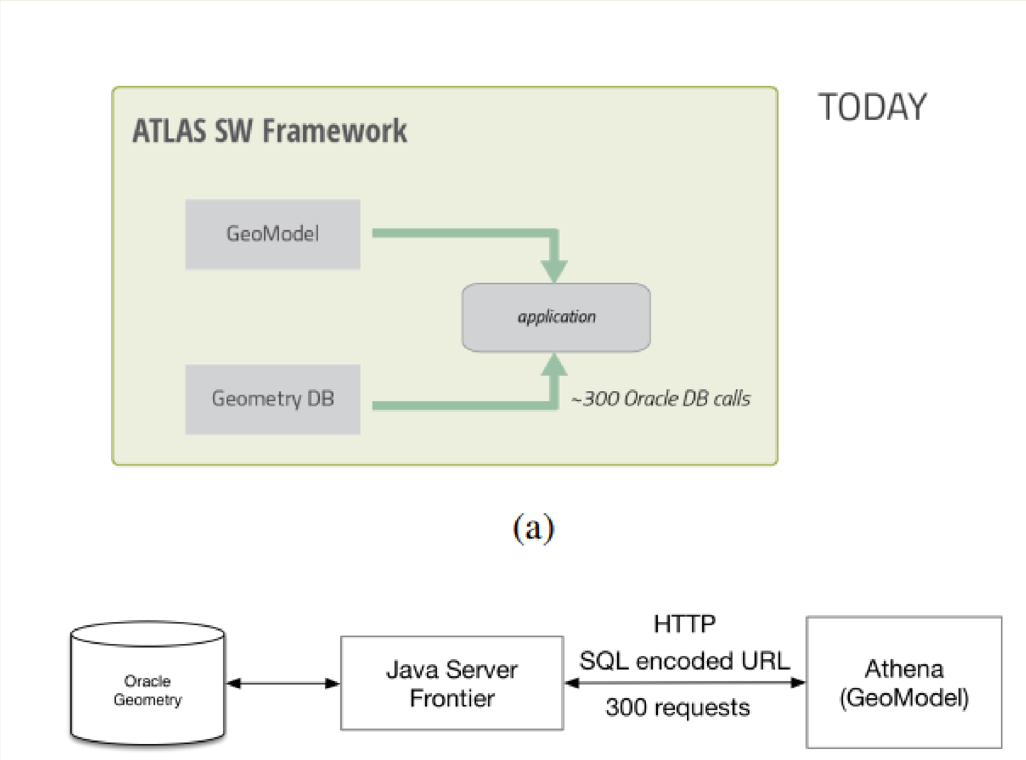
5. Модернизация ПО. REST

Representational State Transfer — это архитектурный стиль взаимодействия компонентов распределённого приложения в сети. Архитектурный стиль – это набор согласованных ограничений и принципов проектирования, позволяющий добиться определённых свойств системы.

6 принципов REST:

- Клиент-серверная архитектура
- Stateless: сервер не должен хранить у себя информацию о сессии с клиентом. Он должен в каждом запросе получать всю информацию для обработки
- Кэширование
- Единообразие интерфейса
- Layered system (слоистая архитектура)
- Code on demand (код по требованию): Идея передачи некоторого исполняемого кода (по сути какой-то программы) от сервера клиенту.

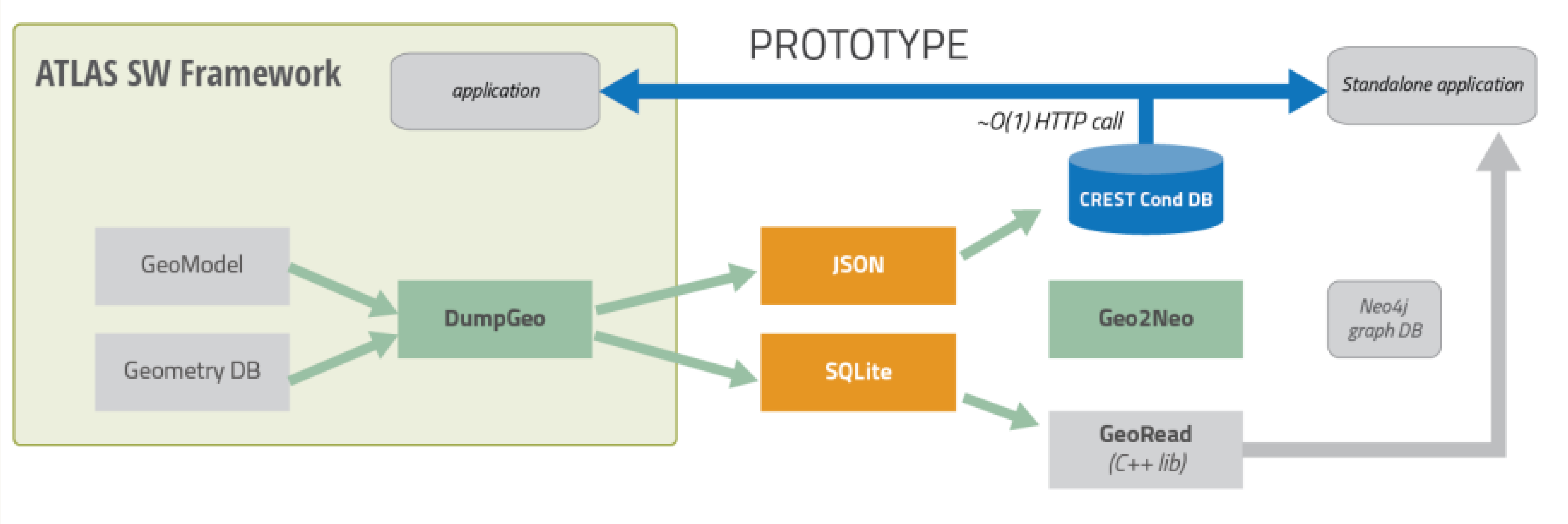
5. Модернизация ПО. Старая архитектура.



a) the architecture currently implemented in ATLAS: the detector description is built on-the-fly, taking the definition of the GeoModel tree from C++ code and the geometry parameters from a dedicated Oracle database though a dedicated service; all operations are performed within the experiment's framework

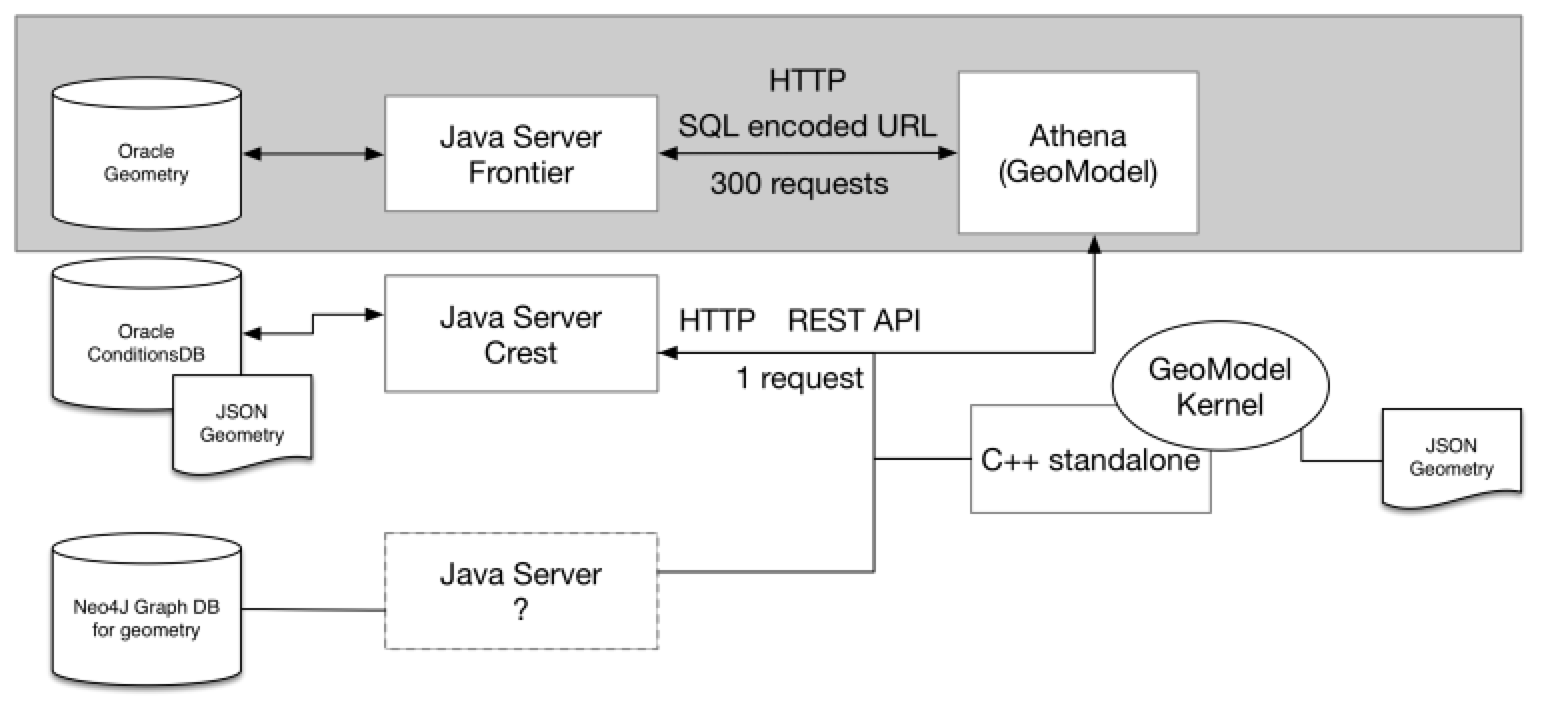
b) The current actors and actions involved in the retrieval of geometry parameters from the Oracle DB. Today, about 300 SQL queries are needed to retrieve the full set of geometry parameters, performed by each of the jobs processing the data.

5. Модернизация ПО. Новая архитектура



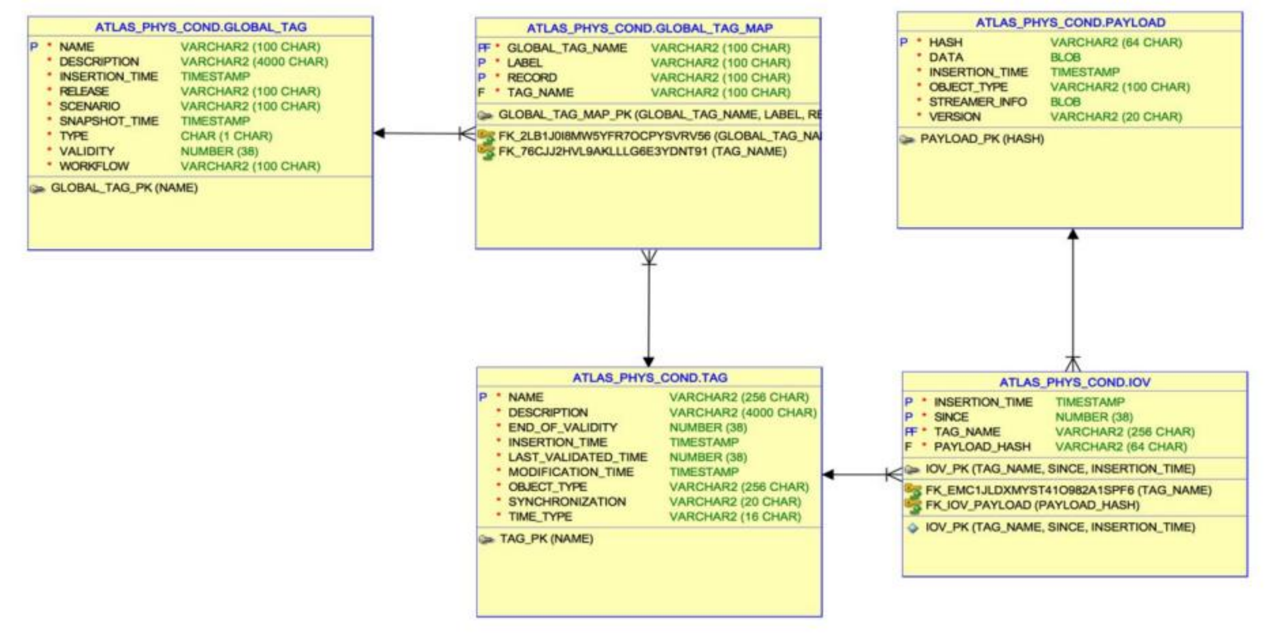
The new architecture. Once the detector description built, a persistent copy of it is saved to files, from which it can be read, served, and queried outside of the experiment’s framework.

5. Модернизация ПО. Интеграция

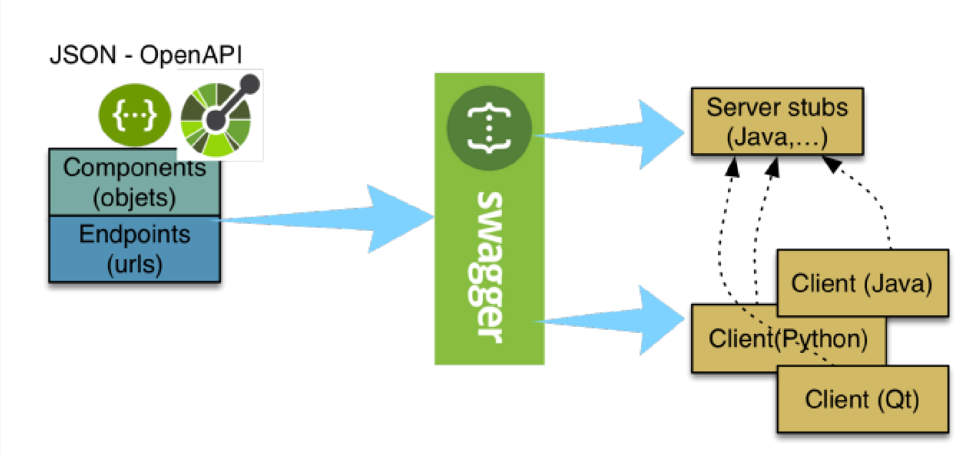


An overview of the new architecture integrating with the current one. In grey, the current system to retrieve the geometry data from the Oracle-based GeometryDB, through the experiment's framework. In the middle, the new architecture, which uses an HTTP REST API to retrieve geometry data from the CREST conditions database, where are stored as JSON blob. The same REST API could be used by standalone applications as well (on the right, in the drawing). At the bottom, a future extension of the architecture is foreseen, querying and filtering geometry data from a Neo4j, graph-database instance.

5. Модернизация ПО. CREST. SWAGGER



CREST data model scheme



For the prototype, the Swagger OpenAPI has been used to generate the server and client code.

Заключение

- В настоящее время идет глобальный процесс модернизации программного обеспечения
- Идет апгрейд программной архитектуры для эксперимента ATLAS
- Перестроение и перенос процессов для использования CREST
- Идет модернизации инструмента PVSS2COOL в PVSS2CREST, в процессе согласование параметров с ответственными в ATLAS

Спасибо за внимание.